California Division of Mines and Geology

Supplement No. 1 to Fault Evaluation Reports FER-78 and FER-83

November 16, 1979

1. Faults: Imperial, Brawley and unnamed fault near Holtville.

2. Location: Southern Imperial County (Figure 1); Brawley, Alamorio, El Centro, Holtville West, Calexico, and Bonds Corner 7.5-minute quadrangles (Sheets 1 to 6).

3. Reasons for Evaluation:

The Imperial Valley earthquake of October 15, 1979 provided an opportunity to map the associated fault rupture in detail and to determined if active fault traces lay where anticipated within the Special Studies Zones (SSZ's) proposed for revision July 1, 1979. At the time of the earthquake, Preliminary Review maps of the Brawley, Alamorio, and Holtville West quadrangles (Sheets 1, 2 and 4) were undergoing review for release as Official Maps on January 1, 1980. Three other SSZ maps of the El Centro, Calexico, and Bonds Corner quadrangles (Sheets 3, 5 and 6), issued in 1974, also needed to be evaluated for zoning effectiveness.

4. References (See FER-78 and FER-83 for other references):

California Division of Mines and Geology, 1974 and 1975, Special Studies Zones, Official Maps of the Brawley, El Centro, Alamorio, Holtville West, Calexico, and Bonds Corner quadrangles. (SSZ's cover the Imperial fault and northern part of the Brawley fault only).

California Division of Mines and Geology, 1979, Special Studies Zones, Revised Official Map for Preliminary Review, Brawley, Alamorio and Holtville West quadrangles. (These maps show proposed zone changes and additions for the Brawley fault and the northern end of the Imperial fault.

Curtis Aerial Surveys, 1979, aerial photographs GS1F, 5 flights of 10/16/79, vertical, black and white, scale about 1:8400 and 1:1800.

Hart, E.W., Fault Evaluation Report FER-83 (Imperial fault): Unpublished report of California Division of Mines and Geology, 4 p., 2 maps (scale 1:24,000).

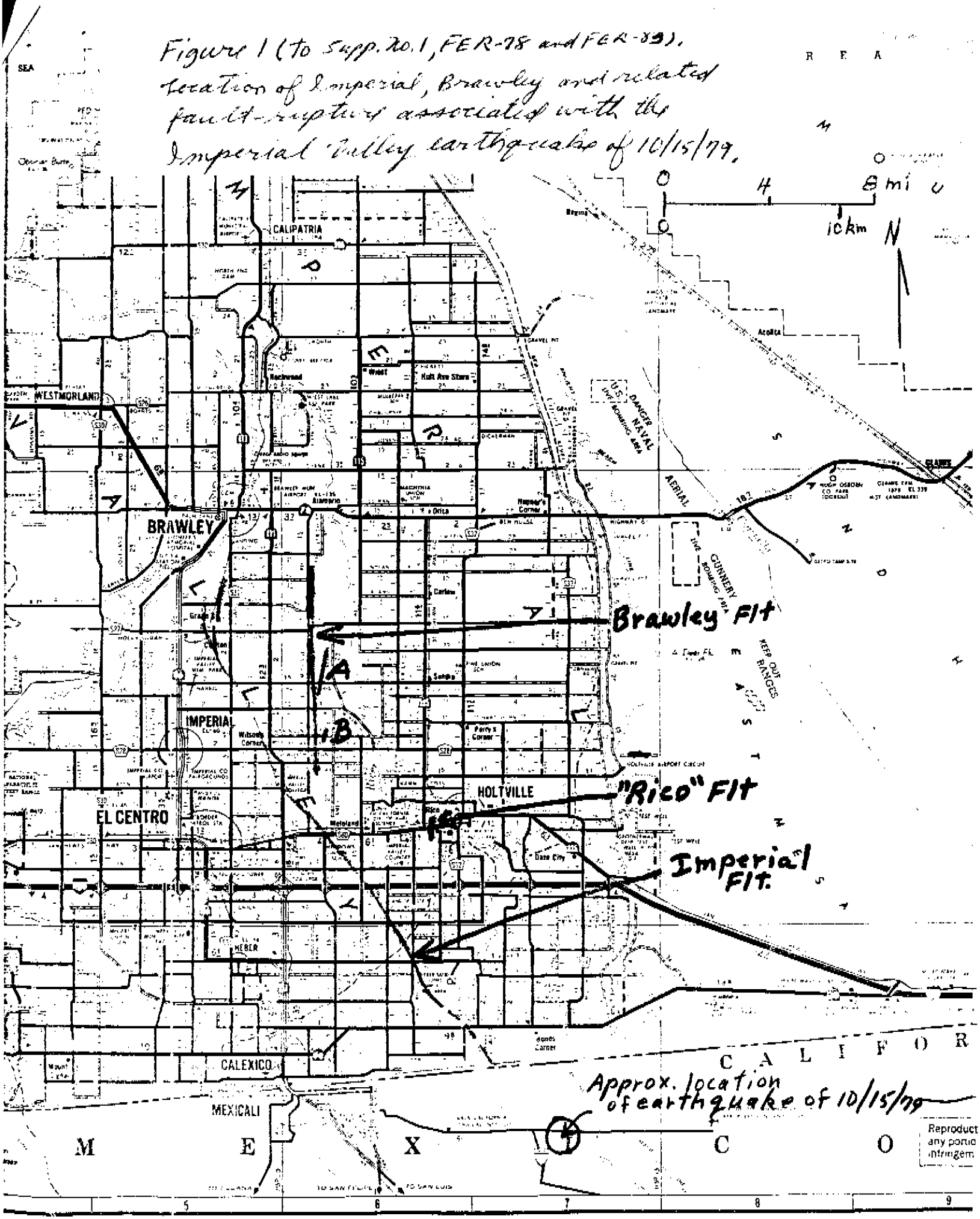
Figure 1 (To Supp. No. 1, FER-78 and FER-83).
Location of Imperial, Brawley and related
fault-rupture associated with the
Imperial Valley earthquake of 10/15/79.
0 4 8 mi
0 4 8 km
N
CALIPATRIA
WESTMORLAND
BRAWLEY
IMPERIAL
EL CENTRO
HOLTVILLE
CALEXICO
MEXICALI
Brawley Flt
"Rico" Flt
Imperial Flt.
Approx. location of earthquake of 10/15/79
M E X I C O
C A L I F O R

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Real, C.R., McJunkin, R.D., and Leivas, E., 1979 (in press), Effects of the Imperial Valley earthquake, 15 October 1979, Imperial County California: California Geology, Dec. 1979, p. 259-265.

Sharp, R.V., 1976, Surface faulting in Imperial Valley during the earthquake swarm of January-February 1975: Bulletin of the Seismological Society of America, v. 66, no. 4, p. 1145-1154.

Sharp, R.V., 1977a, Map showing Holocene surface expression of the Brawley fault, Imperial County, California: U.S. Geological Survey Miscellaneous Field Studies Map MF-838.

Sharp, R.V., 1977b, Holocene traces of the Imperial fault in south-central Imperial County, California: U.S. Geological Survey Open File Report 77-815, 5 sheets (scale 1:24,000).

Smith, D.P., 1978, Fault Evaluation Report FER-78 (Brawley fault): Unpublished report of California Division of Mines and Geology, 6 p., 4 Figures.

5. Observations:

Surface fault-rupture associated with the Imperial Valley earthquake of October 15, 1979 and its aftershocks occurred along the Imperial and Brawley faults northwestward from near the Mexico border almost to Brawley (Figure 1). In addition, two minor branches (Branch A and Branch B, herein) were discovered east of the Brawley fault. Another minor fault (referred to herein as the "Rico fault") was discovered just west of Holtville. "Triggered-slip" type faulting on the nearby San Andreas and Superstition Hills faults (Kerry Sieh, p.c., October 1979), are not considered here.

These faults were observed and mapped in the field during October 17-19 and 24-26. Field assistance was provided by D.R. Fuller and R. Greenwood October 17-19 and by T.L. Bedrossian (Ristau) October 24-26. Additional field observations were made October 16-19 by J.E. Kahle and R.B. Saul. Because most of the area is under intensive agricultural development, it was not possible to trace all faults in the field. The excellent aerial photographs of Curtis Aerial Surveys provided much information on fault locations, continuity, and even amount of displacement. (Individuals interested in the precise locations of the Imperial and Brawley faults are referred

to these photographs). Traces identified on aerial photos were transferred to the topographic basemaps by scaling and by use of a Bausch and Lomb Zoom Transfer Scope. The latter work was done by J.G. Moreno. The assistence of all of these people is greatly appreciated.

The fault locations and observational data plotted on Sheets 1 to 6 are identified as "preliminary" only in the sense that not all of the fault-rupture was observed by CDMG geologists. However, the fault traces observed in the field and on air photos are plotted with care and are believed to be accurate. Data on the magnitude, sense, and timing of fault rupture are incomplete, but they do provide an accurate preliminary assessment of the faulting associated with the October 15, 1979 earthquake. A summary of surface fault rupture for each active fault and principal branches or segments is provided below.

Imperial fault

This fault is considered to be the causative fault for the M6.6 earthquake of October 15, 1979 (Real and others, 1979). The epicenter of the earthquake reportedly was along the Imperial fault in Mexico a few kilometers south of the California border (Figure 1). Surface fault rupture occurred continuously from Heber dunes almost to Brawley, a distance of 30 km (18 miles). Rupture also may have occurred discontinuously southeastward from Heber Dunes an additional 7 km (see Sheets 5 & 6). Fault rupture occurred as narrow zones of cracks, mole-tracks, and scarps which offset many roads and canals.

The sense of fault displacement was largely right-lateral slip on the Imperial fault, although vertical offset (down to the east) was dominant at the north end. Maximum right-lateral slip immediately following the earthquake (coseismic slip) was rougly 0.5 m in the vicinity of Arnholdt Road and Heber dunes. Post-earthquake slip in this same area increased the total slip to

to nearly 0.8 m within 10 days (Kerry Sieh, p.c., 10/30/79). The amount of right-lateral offset decreased rapidly to the southeast and more gradually to the north (just north of Keystone Road). Vertical, down-to-the-east displacement occurred west of State Highway 111. Maximum vertical displacement, commonly distributed across a monoclinical warp a few meters wide, was observed to be 19 cm at Harris Road (Sheet 1) on 10/17/79.

With a single exception, fault rupture along the Imperial fault occurred entirely within the SSZ's shown on Official Maps of 1974 or the revised zone maps of 7/1/79 (Sheets 1, 3, 4, 5, 6). The single exception was in the El Centro quadrangle where about 1000 feet of an active fault lies just west of the existing zone boundary near Aten Road and Highway 111. Based on observed physical features and on the mapping of Sharp, the 1979 breaks appear to be identical to the 1940 ground-ruptures, both in location and in sense of offset. Sharp (1977b) plotted the 1940 breaks along with other recent faults and this served as the basis for proposing revised zones on Sheets 1 and 3. Sharp's portrayal of the Imperial fault was amazingly accurate, considering the lack of adequate base maps after the 1940 event, and his traces appear to be located within 100 feet of the 1979 ruptures for at least 90% of the length of the Imperial fault.

Brawley fault

The Brawley fault was first discovered in 1975 following ground rupture associated with the earthquake swarm of January-February 1975 (Sharp, 1976). Using preliminary CDMG observations (Kahle, 1975, unpublished map), an SSZ map was established for the fault traces in the Alamorio quadrangle. Based on

detailed mapping and aerial photo interpretation, a subsequent report (Sharp, 1977a) delineated the active fault traces in the Alamorio quadrangle and showed the fault to extend southward into the Holtville West quadrangle. Consequently, CDMG proposed new and revised zones for these two maps and planned to release Official Maps on 1/1/80.

The fault rupture observed in association with the 10/15/79 earthquake and its principal aftershocks (3 near Brawley were measured at 5.2 M to 5.8 M) extended along the Brawley fault for 13 km (about 8 mi.) (Sheets 2 and 4). Maximum displacements measured were 15 cm of dip slip (down to the west) and 3 cm right- lateral slip. However, vertical displacement may have exceeded the observations if offset were distributed over warps greater than 2-3 m wide. Detailed levelling surveys underway by the U.S. Geological Survey will provide a more accurate assessment of the vertical offsets (R.V. Sharp, p.c., Oct. 1979).

With 3 exceptions, all of the 1979 breaks were within the proposed SSZ's (Sheets 2 and 4). Most of the 1979 fault rupture followed the course of previous breaks identified by Sharp (1977a). The exceptions;

1. The northernmost trace extended 0.65 km farther north than was previously known (Sheet 2).
2. A new fault, Branch "A", was discovered to the east of the main fault and well-outside of the proposed SSZ (Sheet 2). It showed as much as 12 cm vertical offset. Terrace level differences across the fault (at least 5 feet along Harris Road) indicate the pre-existence of a west-facing scarp and previous Holocene faulting.
3. Another minor fault (Branch "B" on Sheet 4) was found to the east of the fault and outside of the proposed SSZ.
4. Minor faulting also occurred at the SSZ boundary in sec. 24, T.14S., R.14E., Sheet No. 2.

"Rico fault"

Another probable fault, not known prior to the 10/15/79 earthquake, was initially reported by the USGS (J. Lienkamper and R.V. Sharp, p.c. 10/17/79). The fault-like feature is referred to as the "Rico fault" based on its proximity to the Rico RR Siding. The feature offsets State Highway S80, a railroad track, another paved road and a building about 10 cm along a well-defined west-facing scarp (warp) 2-3 m wide. Except in the irrigated fields on both sides of S80, the fault can be traced a distance of 1.1 km. Because the fault could not be traced through the crops on either side of S80, it cannot be proven that the observations relate to a single feature. Moreover, liquefaction - caused ground settlement in the general vicinity may suggest lateral-spreading as a possible cause of the fault-like feature(s). Nonetheless, faulting appears to be the probable cause of this ground displacement. The existence of a pre-existing, low, west-facing scarp indicates previous Holocene displacement across the "Rico fault".

6. Conclusions:

As a result of the fault rupture associated with the Imperial Valley earthquake of 10/15/79, it is concluded that:

a. The Imperial fault ruptured along the same traces as the 1940 event. With minor exceptions, these traces were well-mapped by Sharp (1977b) and lie within the proposed or existing SSZ's.

b. The Brawley fault was reactivated along most of the traces identified by Sharp (1976 and 1977a) as being active during 1975. However, two new branches (one minor) were discovered after the 1979 event and both of these appear to lie along pre-existing fault scarps outside of the proposed SSZ's. The most northerly trace was found to extend 0.65 km farther north than was shown by Sharp (1977).

c. The "Rico fault is a minor fault-like feature discovered as a result of the 1979 earthquake. A probable pre-existing scarp suggests previous displacements and the probability of recurrent vertical offset.

7. Recommendations:

The following zoning recommendations are made with reference to the proposed new SSZ's shown on the Preliminary Review Maps of 7/1/79 of the Brawley, Alamorio, and Holtville West quadrangles.

a. It is recommended that the Imperial fault traces of Sharp (1979b) be modified to accommodate the new data on fault trace locations and that minor adjustments be made to the SSZ boundaries Sheets 1 and 3).

b. It is recommended that the proposed zone revisions for the Brawley fault be based on the newly determined fault locations (Sheets 2 and 4), as well as the traces of Sharp (1976, 1977a). SSZ boundaries should be adjusted accordingly.

c. It is recommended that the "Rico fault" be added to the Holtville West map and zoned (Sheet 3). Although it is a minor feature, it is well-located and there is evidence of repeated displacement along it.

It is further recommended that the Official Maps of SSZ's of July 1, 1974 (El Centro, Calexico, and Bonds Corner quadrangles) be revised based on the new fault data resulting from the 1979 Imperial Valley earthquake. This should be done as soon as possible, but after final maps are prepared by the U.S. Geological Survey (they plan to publish a Professional Paper sometime in early 1980). The existing Official Maps are still serviceable, but they do not everywhere accurately locate the active traces of the Imperial fault.

8. Report prepared by: Earl W. Hart
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